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MANAGEMENT OF WATER IN THE PREMISES
BY
RAIN WATER HARVESTING,
GREY WATER HARVESTING
&
FASTENING AND FIXTURES

Submitted in partial fulfillment of the requirements

of the the degree of

Bachelor of Engineering (B.E)

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Under guidance of

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This is to certify that the project entitled " ***Management of Water In The Premises By Rainwater Harvesting, Grey Water Harvesting & Fastening and Fixtures."*** is a bonafide work of ***"Ms. JADHAV NIKITA NARAYAN (13CES02)"*** submitted to the ***University of Mumbai*** in partial fulfillment of the requirement for the award of the degree of ***"Bachelor of Engineering"*** in ***Department of Civil Engineering***.

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PROJECT REPORT APPROVAL FOR B.E.

This project report entitled **"Management Of Water In The Premises By Rainwater Harvesting, Grey Water Harvesting & Fastening and Fixtures"** by **"Ms. NIKITA NARAYAN JADHAV (13CES02)"** is approved for the degree of " **Bachelor of Engineering"** in **" Department of Civil Engineering".**

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DECLARATION

I declare that this written submission represents our ideas in our own words and where others ideas or words have been included; I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. I understand that any violation of the above will be caused for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not have been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

The forest covers are decreasing. Hence water and soil hold by roots, plants are degraded. And it is affecting hydrological cycle, badly. This is resulting in tremendous increase in depth of groundwater level. It is high time to implement rainwater harvesting projects. These technologies are simple and easy to install and to operate. A precious source of water availability has become scarce, hence the need for conservation. The development of water resources in the premises of college campus. An optimum development can be achieved by conjuctive use of surface water or runoff. Rainwater Harvesting is the concept, which includes a approach to develop, protect and conserve water resources. Rainwater Harvesting is artifical recharge of groundwater resources and it is commonly adopted and cost effective method of replenishing the ground water reserves.

India is facing a water crisis and by 2025 it is estimated that India's population will be suffering from severe water scarcity. Although India occupies only 3.29 million km^2 geographical area which forms 2.4% of the worlds land area, it supports over 15% of world's population with only 4% of the world's water resources. With increased population growth and development, there is a need to critically look at alternative approaches to ensure water availability. These alternative resources include rainwater and bulk of water used in household will emerge as grey water and contain some minerals, organic waste materials dissolved and suspended in it. When this is allowed to flow out this will join the sewage and bacteriologically contaminated, resulting in a sewage stream. It is possible to intercept this grey water, at the household level, treat it so that it can be recycled for garden washing and flushing purposes. The main reason behind this treatment requirement people's perception, high initial cost and ignorance about payback period.

Fixtures and fastenings are used to save the water by using the new technology. Like using air faucets, pressurized taps and sensor taps. So that the quantity of water used will be less because of more pressure of air less water is utilized.

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Chapter 1

Introduction

1.1 Condition of Rainfall:

1.1.1 In The World:

The Major cause of rain products is moisture moving along three-dimensional zones of temperature and moisture contrasts known as weather fronts. If enough moisture and upward motion is present, precipitation falls from convective clouds such as cumulonimbus which can organize into narrow rain bands.

Global Warming is also causing changes in the precipitation pattern globally including wetter conditions across eastern North America and drier conditions in the tropics. Antarctica is the driest continent. The globally averaged annual precipitation over land is 715mm, but over the whole Earth it is much higher at 990mm.

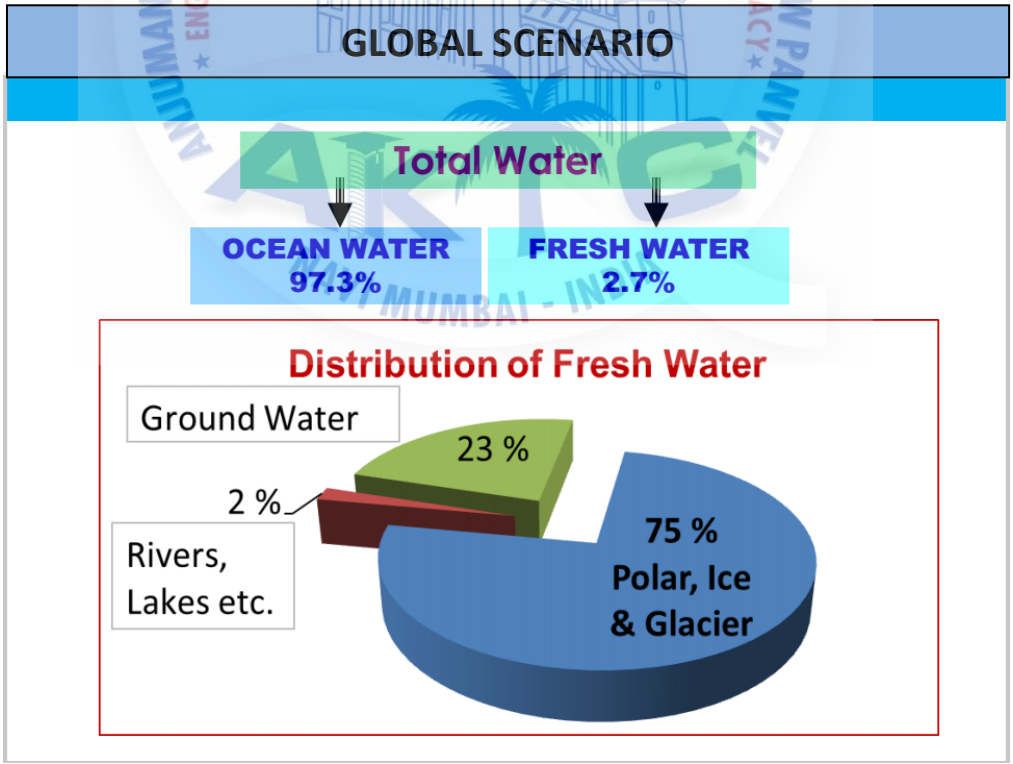


Figure 1.1: Global Water distribution

- **Water Crisis:**

When there is not enough portable water for a given population, the threat of water crisis is realised. The United Nations and other world organizations consider a variety of regions to have water crisis of global concern. Other organizations such as Food and Agriculture Organization, argue that there are no water crisis in such places, but steps must still be taken to avoid one. Inadequate access to safe drinking water for 884 million people. Inadequate access to sanitation for 2.5 billion people, which often leads to water pollution. Groundwater overdrafting leading to diminished agricultural yields. Overuse and pollution of water resources harming bio-diversity. Regional conflicts over scarce water resources sometimes resulting warfare. Waterborne diseases caused by lack of sanitation and hygiene are one of the leading causes of death worldwide. It has also been claimed, primarily by economists, that the water situation has occurred by lack of property rights, government regulations and subsidies in the water sector, causing prices to be low and consumption to be high.

Water is the underlying tenuous balance of safe water supply, but controllable factors such as the management and distribution of water supply itself contribute to further scarcity.

There are many countries of the world that are severely impacted with regard to human health and inadequate drinking water. The following is a partial list of some of the countries with significant populations whose only consumption is of contaminated water:

- Sudan 12.3 million
- Venezuela 5.0 million
- Ethiopia 2.7 million
- Tunisia 2.1 million
- Cuba 1.3 million

After China and India, there is a second tier of smaller countries with large water deficits- Algeria, Egypt, Iran, Mexico, and Pakistan. Four of these already import a large share of their grain. But with a population expanding by 4 million year, they will also likely soon turn to the world market for grain. Water scarcity has many negative impacts on the environment, including lakes, rivers, wetlands, and other fresh water resources. The resulting water overuse that is related to water scarcity, often located in the areas of

irrigation agriculture, harm the environment in several ways including increased salinity, nutrient pollution, and the loss of floodplains and wetlands. Furthermore, water scarcity makes flow management in the rehabilitation of urban streams problematic.

Globally, rain is the main source of fresh water for plants and animals rainfall is essential for life across Earth's landscapes. In addition to moving tremendous amounts of water through Earth's atmosphere, rain clouds also move tremendous amounts of energy. When water evaporates from the surface and rises as vapor into the atmosphere, it carries heat from the sun-warmed surface with it. Later, when the water vapor condenses to form cloud droplets and rain, the heat is released into the atmosphere. This heating is a major part of Earth's energy budget and climate.

The rainfall maps show total monthly rainfall in millimetres as recorded by NASA's Tropical Rainfall Measuring Mission (TRMM) satellite, which is a joint mission between NASA and the Japanese Space Agency. High rain totals are represented in dark blue, while small rainfall totals are shown in white. TRMM measures rainfall in the tropics. High-latitude regions, where TRMM does not record rainfall, are gravy.

The most obvious pattern in the total rainfall maps is seasonal change. A band of heavy rain moves north and south of the Equator seasonally. In fact, about two-thirds of all rain falls along or near the equator, and countries in those latitudes often have several months of near-daily rain followed by months of dryness as the rain band moves north and south. The Asian monsoon brings rain to China, Southeast Asia, and India between April and September. From October through May, South America goes through a rainy season, but even parts of the Amazon Rain forest goes a few months each year without significant.

1.1.2. In India:

India receives 80% of its annual rainfall during the south-west monsoon season of June to September. Rainfall over the country during this season shows a wide range of spatial variation due to orographic influences and preferential occurrence of rain-bearing systems in certain regions. India has a very extensive rain gauge network and rainfall monitoring over the country is a stupendous task.

The real-time monitoring and statistical analysis of distinctive daily rainfall is one of the important functions of the Hydro-meteorological Division of IMD at New Delhi. Based on the real time daily rainfall data, weekly districtwise, sub-division wise and state wise rainfall distribution summaries are prepared regularly by the Rainfall Monitoring Unit.

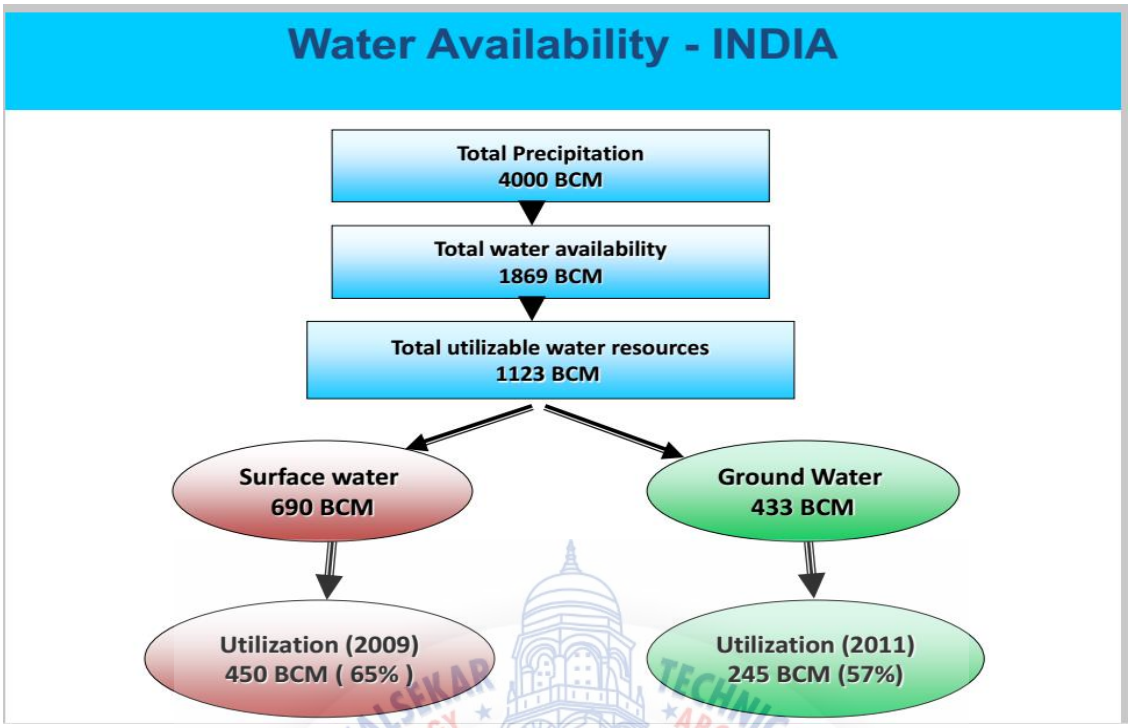


Figure 1.2: Available Water in India

Sector wise Future Demand (BCM)

Sector	Probable Water Demand as Projected by NCIWRD (1999)	
	2025	2050
Irrigation	611	807
Domestic	62	111
Industry	67	81
Energy	33	70
Others	70	111
Total	**843**	**1180**

Figure 1.3: Sector wise future demand

A. Pan India Potential:

No authenticated potential of rainwater harvesting has been assessed in India. On absolute local basis it has been carried out at some places.

- **Tamil Nadu:**

Tamil Nadu was the first state to make Rainwater Harvesting compulsory for every building to avoid groundwater depletion. The scheme was launched in 2001 and has been implemented in all rural areas of Tamil Nadu. We can see posters all over Tamil Nadu including rural areas to create awareness about harvesting Rainwater TN Got site. It gave excellent results within five years, and slowly every state took it as a role model. Since its implementation, Chennai saw a 50 percent rise in water level in five years and the water quality significantly improved.

- **Karnataka:**

In Bangalore it is mandatory for adoption of rainwater harvesting for every owner or the occupier of a building having the sisal area measuring 60 ft. (18.3 m) X 40 ft. (12.2 m) and above and for newly constructed building measuring 30 ft. (9.1 m) X 40 ft. (12.2 m) and above dimension. In this regard, BWSSB has initiated and constructed "Rain Water Harvesting Theme Park" in the name of Sir. M. Visvesvaraya in 1.2 acres (4,900 m2) land situated at Jayanagar, Bangalore. In this park, 26 different type of Rain Water Harvesting models are demonstrated along with the water conservation tips. The Auditorium on the first floor is set up with Green Air conditioning system and the same will be utilized to arrange the meeting and showing the video clip about the rainwater harvesting to students as well as general public.

- **Rajasthan:**

In Rajasthan, rainwater harvesting has traditionally been practiced by the people of the Thar Desert. There are many ancient water harvesting systems in Rajasthan, which have now been revived. Water harvesting systems are widely used in other areas of Rajasthan as well, for example the chauka system from the Jaipur district.

- **Maharashtra:**

At present, in Pune, rainwater harvesting is compulsory for any new housing society to be registered.After bouncing good rains over most parts of Maharashtra and particularly over Mumbai, it seems that rains have now bid adieu to the state. From past few days, Mumbai has been thriving for good rains but unfortunately, not much showers had been recorded.

1.1.3. In Mumbai:

In Mumbai city in Maharashtra rainwater harvesting is being considered as a good solution to solve the water crisis.The Mumbai city council is planning to make rainwater harvesting mandatory for large societies.

- **Monthly breakdown of climate:**

The following is the monthly breakdown of the weather in Mumbai city.

January:

January is the coolest month of the year for Mumbai with mean daily minimum being. The days are dry, the nights relatively humid. January is also associated with the deciduous trees in the city shedding their leaves.

February:

The fine January weather continues for the first fortnight of February. Smog increases.

March:

Humidity is unbearable, and smog affects the city. New leaves sprout from deciduous trees.

April:

The temperatures and humidity are still high. However, the cooling effect of the sea breezes makes its presence felt. The cool winds compensate for the heat. Which means the days highest temperature stays around 33.1 °C and means daily lows are around 23.7 °C. Plants are in full bloom in April.

May:

May is the hottest month of the year for Mumbai with the cool sea breezes providing some relief.

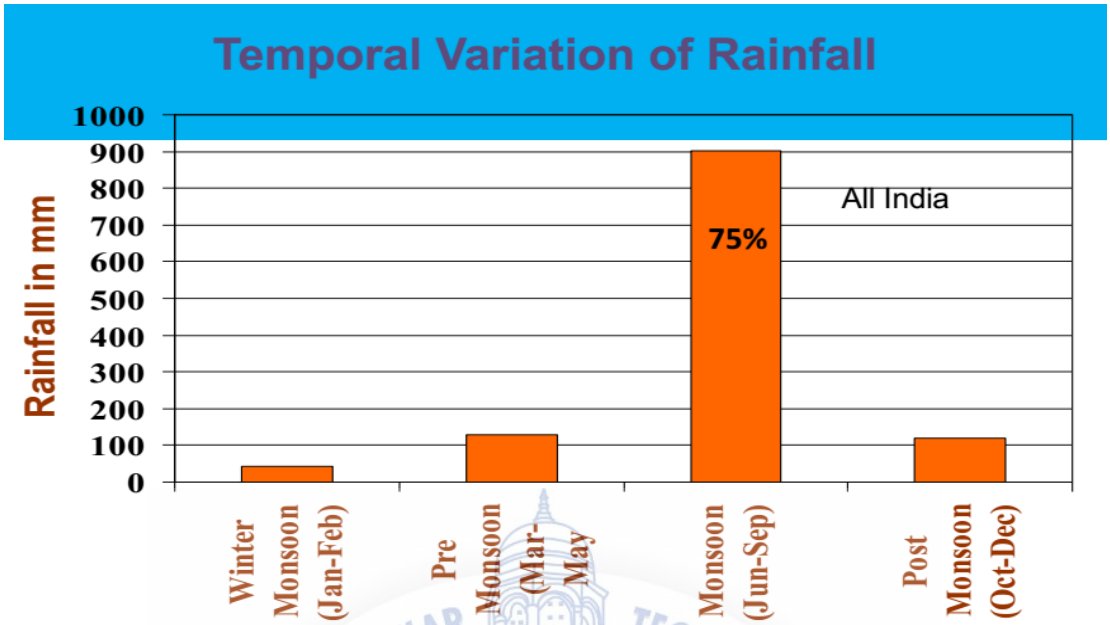


Figure 1.4: variation of rainfall through out the year

Even in monsoon season, the rainy days are limited. On an average there are about 20-25 rainy days for 120 days (june-sept), resulting in rains for just 100-150 hours of rainfall.

June:

June marks the beginning of the monsoon period in Mumbai. The beginning of the month is characterized by a continuation of the summer with increased humidity. The official date for the monsoon to hit the city is 10 June. This period is marked by thunderstorms and often windy conditions as the monsoon establishes itself over the city. Rainfall activity intensifies as the month goes on, leading into wettest month, July.

July:

In this month the city receives the maximum amount of rain. July and August are characterized by almost non stop rain and weeks of no sunshine. A continuous monsoon current covers the entire western coast of India during this period. Rainfall activity is less

stormy and more constant with a relatively constant breeze from the West or South West. It is not uncommon for parts of the city to be waterlogged during periods of persistent heavy rain. This affects the city's public transport system often leading to long delays. During periods of severe precipitation, the city's commuter rail system is often suspended because of water logging and poor visibility.

August:

The weather in August is almost identical to July. Towards the latter half of the month, rainfall activity tends to lessen. The coolest days of the monsoon season are often in August.

September:

In September the intensity of rainfall decreases. The monsoons officially end in the 3rd week of September. September has unsettled weather. The rainfall is short and light and is not continuous. The end of the monsoon, much like the beginning can feature heavy thunderstorms associated with the withdrawal of the monsoon current from the city and surrounding areas.

October:

Hot during the days and cold during the nights.

November:

The temperature continues to drop slowly in the month of November. There are a few nonseasonal showers.

December:

Humidity is low.

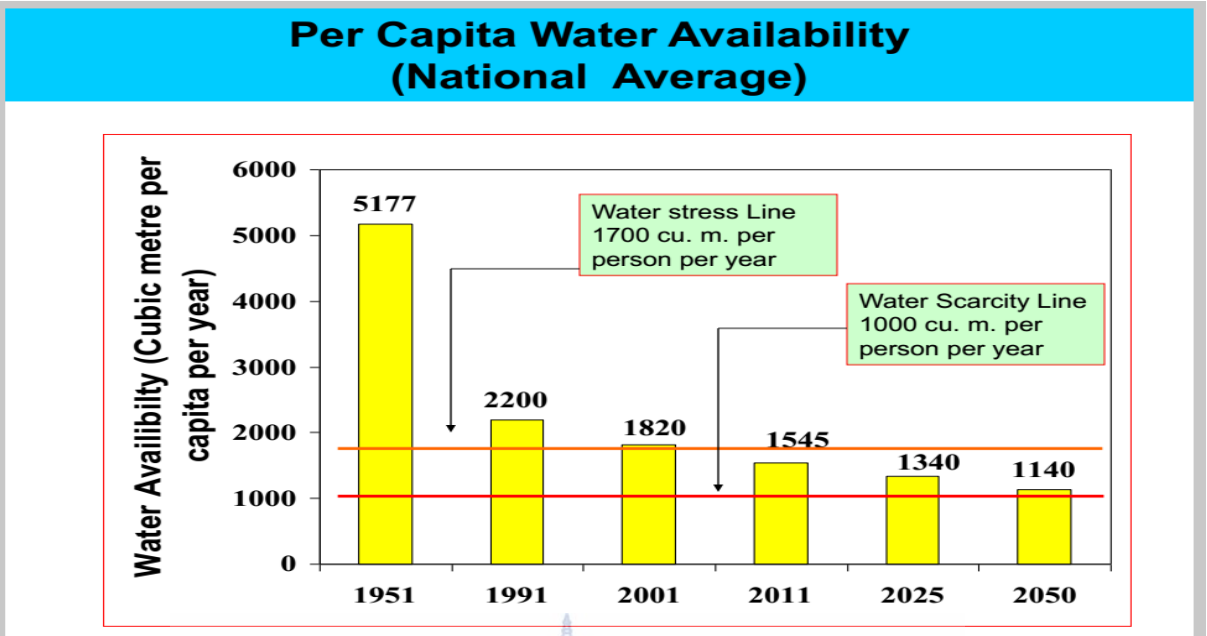


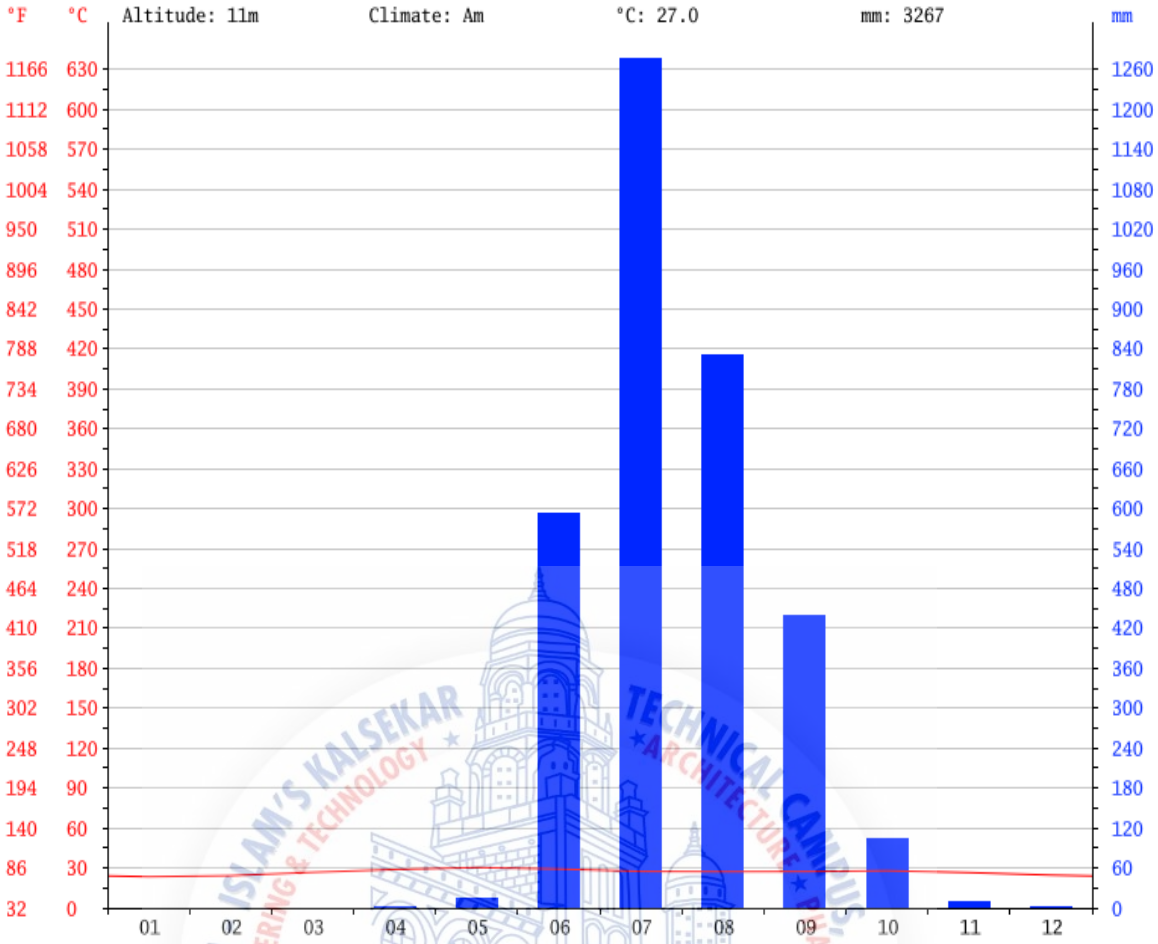
Figure 1.5: Water available per capita per year

Issues at glance:

- 17% of World's population, 4% of renewable water resources, 2.5% land area.
- Most of the basins in western part and peninsular India already water scarce (per capita availability is less than 1000m^3 per person per year)
- Over-Exploitation of groundwater resources, leading to rivers getting dry in lean season.

1.1.4 in Panvel:

Panvel is located at 73.1E longitude and 18.98N latitude in Raigarh district of Maharashtra at an elevation of about 12 meters above mean sea level. Raigarh has a tropical climate and receives high rainfall during Southwest monsoon (June-September) and retreating Northeast monsoon (December-January). Average annual rainfall is 1276mm.



Graph 1.1: Showing rainfall In Panvel city

Table 1.1: Condition of ground water in Raigarh district

Sr No.	Taluka	Wells Drilled		Depth (m bgl)	SWL (m bgl)	Discharge (lps)	Zones Encountered (m bgl)
		EW	OW				
1	Alibaug	3	0	187-200	3.8	0.14-0.38	-
2	Karjat	2	0	200	6	Traces-0.38	-
3	Khalapur	5	2	116-200	8.93-9	0.38-15	54.79

4	**Mahad**	**6**	**4**	**75-200**	**1.18->100**	**0.05-12.18**	**10-101.6**
5	**Poladpur**	**2**	**2**	**150-200**	**4.5-9**	**Traces-12.18**	**16-137**
6	**Mangaon**	**6**	**2**	**184.30-200**	**0.6-85**	**0.38-8.75**	**12-196**
7	**Mhasala**	**1**	**0**	**200**	**5.2**	**1.8**	**-**
8	**Murud**	**1**	**0**	**75**	**4.5**	**5.94**	**16-18**
9	**Panvel**	**4**	**0**	**84-200**	**8. 11-11.6**	**0.24-3.17**	**95**
10	**Pen**	**4**	**3**	**93-175**	**2.69-16.69**	**0.14-29.16**	**79-172**
11	**Poladpur**	**2**	**2**	**150-200**	**4.5-9**	**3.77-12.18**	**16-137**
12	**Roha**	**7**	**2**	**140.6-201.3**	**1.0->50**	**Traces-12.18**	**7-184**
13	**Sudhagarh (pali)**	**2**	**1**	**46.5-145.5**	**2.35-4.92**	**0.38-7.76**	**17-139**
14	**Tala**	**2**	**0**	**193.3-200**	**6.2-6.32**	**0.78-2.16**	**10-150**
	Total	**47**	**18**	**46.5-201.3**	**0.60->85.00**	**Traces to 29.16**	**12-196**

- **Groundwater Quality:**

CGWB is monitoring the ground water quality of the Raigad district since the last four decades through its established monitoring wells. The objectives behind the monitoring are to develop an overall picture of the ground water quality of the district. During the year

2011, the Board has carried out ground water quality monitoring of 20 monitoring wells. These wells, mainly consist of dug wells representing shallow aquifer. The sampling of ground water from these wells was carried out in Month Of May (pre-monsoon period). The water samples after collection were immediately subjected to the analysis of various parameters in the regional chemical lab of the board at Nagpur. The parameters analyzed, include pH, electrical conductivity, total alkalinity, total hardness, nitrate (NO_3) and fluoride (F). The sample collection preservation, storage, and analysis were carried out as per the standard methods given in the manual of American Public Health Association for the examination of water and waste water (APHA, 1998).

- **Suitability of ground water for drinking purpose:**

The suitability of ground water for drinking purpose is determined keeping in view the effects of various chemical constituents in water on the biological system of human being though many ions essential for the growth of human, but when present in excess have an adverse effect on human body. The Standards proposed by BIS for drinking water (IS-10500-91, Revised 2003) used to decide suitability of groundwater.

Table 1.2: classification of ground water

CLASSIFICATION OF GROUND WATER SAMPLES FOR DRINKING BASED ON BIS DRINKING WATER STANDARDS (IS-10500-91, Revised 2003)

Parameters	DL	MPL	Samples with conc. < DL	Samples with conc. in DL-MPL	Samples with conc. >MPL
TH (mg/L)	300	600	19	Nil	1
NO_3 (mg/L)	45	No relaxation	19	-	1
F (mg/L)	1.0	1.5	20	Nil	Nil

(Here, DL- Desirable Limit, MPL- Maximum Permissible Limit)

From above studies we can conclude that there is water crises because of low rainfall and ground condition is not good for using sufficient water from it. For the fulfillment of the water demand we are going for rainwater harvesting. Grey water harvesting will be for gardening and washing of floors. And by that we can also recharge the ground water.

Chapter 2

Literature review

2.1: General:

This chapter reviews the literature relevant to the objective of the study, i.e., Management of water in the premises by rainwater harvesting, grey water harvesting & fastening and fixtures, as well the information on development of its components. A brief review on complete analysis and designing of different component of the system has also been included. A discussion on the purpose of rainwater harvesting i.e. storing harvested water in tank after different available way of filtration and different component and ways of recharging ground aquifer for increasing the water table level and increasing soil moisture condition for good agriculture purpose has also been incorporated. Again, on recharging underground water by grey water harvesting can be fetched out by pumping.

2.1.1 International Journal of Scientific & Engineering Research, Volume 4, Issue 8, (August-2013):

It is no denying that sustaining and recharging the groundwater along with judicious use of the limited fresh water resources is the need of the hour. If sufficient measures are not taken up immediately, we will face a crisis which will be detrimental to the very survival of mankind. Efficient management of water resources and education about judicious utilization of water resources along with measures of harnessing, recharging and maintaining the quality of water and water bodies has to be taken up on war footing.

2.1.2 Rooftop Rainwater Harvesting (RRWH) At SPSV Campus, Visnagar: Gujarat-A Case Study:

Rain water harvesting project is the best approach to fight the present scenario of water scarcity in all aspects in financial point and also utilization of runoff water. By implementation in water harvesting project in S.P.S.V. campus we can make little noble cause for rain water conservation which will be beneficial to the students of campus. It may also helpful to the campus. Our campus will become an example to others for rain water harvesting and if our campus would apply this than surely it will be in benefit. This paper fulfilled with all aspect of improving the water scarcity problem in the S.P.S.V. campus by implementing ancient old technique of rainwater Harvesting.

2.1.3 BMA briefing paper (2014):

The system involves collecting water that falls on zinc, asbestos or tiles roof of a house during rainstorms, and conveying it by aluminium, PVC, wood or plastic drain or collector to a nearby covered storage unit cistern. RW yield varies with size and texture of catchment area. A smoother, cleaner and more impervious roofing material contributes to better water quality and greater quantity.

2.1.4 Rajiv Ganguly, Bansal A, Mishra M and Kumar A (2014):

The study shows judicious storing of rain water all-round the year and not only it can be stored for summer without incurring any significant losses. Further, construction pattern of houses in Shimla (sloped roof structures) already provides an advantage in storing rainwater efficiently. The non-dimensional design parameters can be applied for any place which experiences a scarcity of water. The paper also presents a simple benefit-cost ratio for designed RWH system.

2.1.5 Shubham Jain, Pankaj Thakur, Mehul Shrivastava (2015):

In this study an attempt has been made to study the design of roof top rainwater harvesting tank for Katpadi region Vellore district of Tamil Nadu. Based on the rainfall and population density data of the year 2014, the design parameters for the rain water harvesting system have been developed and thus an optimum tank size has been determined. Study reveals that an optimum tank size of 23m3 is sufficient for the maximum storage of rainwater water during the dry season.

2.1.6 Ferdinand Mudatenguha, Jennifer Anena, Clement K Kiptum (2014):

In situ rain water harvesting offers an alternative option to reduce rainwater runoff, increase infiltration and storage of water in soil and reduce the effects of drought stress on maize grain yield. The objective of the study was to assess the effects of in situ water harvesting techniques on soil moisture content, maize growth. The results of this study indicate that mulching, tied ridges and pot holes, in decreasing order of effectiveness, have potential to increase soil moisture content and reduce the damage caused by drought stress to maize growth and grain yield and therefore recommended for farmers in Nyagatare and other drought prone regions.

2.1.7 Second International Conference on Emerging Trends in Engineering (SICETE) Dr.J.J.Magdum College of Engineering, Jaysingpur:

The benefits of greywater recycling include: Reduced use of freshwater, Less strain on septic tanks or treatment plants, More effective purification, Feasibility for sites unsuitable for a septic tank, Reduced use of energy and chemicals, Groundwater recharge, Plant growth, Reclamation of nutrients, Increased awareness of, and sensitivity, to natural cycles .Saving water per day . Saving of 750 to 1000 liter water per day in residential schools (ashrams) /hostels of 50 children. Saving of drinking water by reuse of grey water. Grey water reuse for toilet flushing and gardening.

2.1.8 Feasibility of recycling grey water in multi-storey buildings in Melbourne:

With increasing population water demand is increasing day by day, but resources of fresh water are limited. Among several possible water conservation and recycle schemes, implementation of grey water recycling is scarce. It is found that combined implementation of greywater recycling and water conserving devices is very feasible for multi-story buildings. For a 20storey building, a payback period of only 4.1 years is achievable and for higher no. of floors it drops down to 2.8years. However, this study provides a general insight of looking greywater recycling in a positive way.

2.1.9 Arun Kumar Dwivedi and Sudhir Singh Bhadauria (2009):

The paper is based on the analysis of survey record of around 50 houses of different rooftop areas of peri-urban area of Dhule city. The estimation of the appropriate size of the water tanks and their costs required to fulfill the annual drinking water demands through Domestic Rooftop Water Harvesting (DRWH) from rooftop of different areas are done. A mathematical equation expressing the relationship between the required size of water tank and different rooftop areas is developed. The DRWH systems for all houses are designed considering the existing rain water outlets and cost estimation for each individual house is done. A cost model expressing the relationship between rooftop area and cost of DRWH system is developed.

2.1.10 Abeer Albalawneh, Tsun-Kuo Chang (2015):

In this study, we reviewed greywater characteristics and various treatment technologies with the aim of coming up with the schematic of greywater recycling system designed specifically for restricted agricultural irrigation reuse. Characteristics of greywater are highly variable; greywater amount varies from 50% to 80% of the wastewater volume produced by households. All types of greywater show good biodegradability in terms of

COD: BOD5 ratios. Technologies used for greywater treatment are classified into physical, chemical, biological, and natural systems, or a combination of these. Using physical greywater treatment processes solely as the main treatment method is insufficient for greywater treatment, chemical greywater treatment processes are attractive for single household low-strength greywater treatment systems, as the variability in the strength and flow of the greywater did not affect their treatment performance. Constructed wetland can be regarded as the most environmentally friendly and cost-effective technology for greywater treatment and reuses. Finally, the study suggests the possible greywater recycling scheme for agricultural irrigation reuse purposes.

2.1.11 Shaikh, SK Sameer, SK Younus (2014):

The present study demonstrate the reuse and treatment of residential bathrooms, basins waste water called as grey water for the purpose of landscaping, gardening, irrigations, plant growths and toilet flushing. Based on finding of this study, this treatment technology can be considered as a viable alternative to conventional treatment plants in rural region since they are characterized by high potential for BOD, TDS, TSS, total hardness, oil and grease, anions and cations removal. The benefits found are low energy demand, Less operating and maintenance cost, lower load on fresh water, less strain on septic tank, highly effective purification, and ground water recharge.

Chapter 3

Water management methods

3.1 Rainwater Harvesting:

Rainwater harvesting is the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to run off. Rainwater can be collected from rivers or roofs, and in many places the water collected is redirected to a deep pit (well, shaft, or borehole), a reservoir with percolation, or collected from dew or fog with nets or other tools. Its uses include water for gardens, livestock, irrigation, domestic use with proper treatment, and indoor heating for houses etc. The harvested water can also be used as drinking water, longer-term storage and for other purposes such as groundwater recharge.

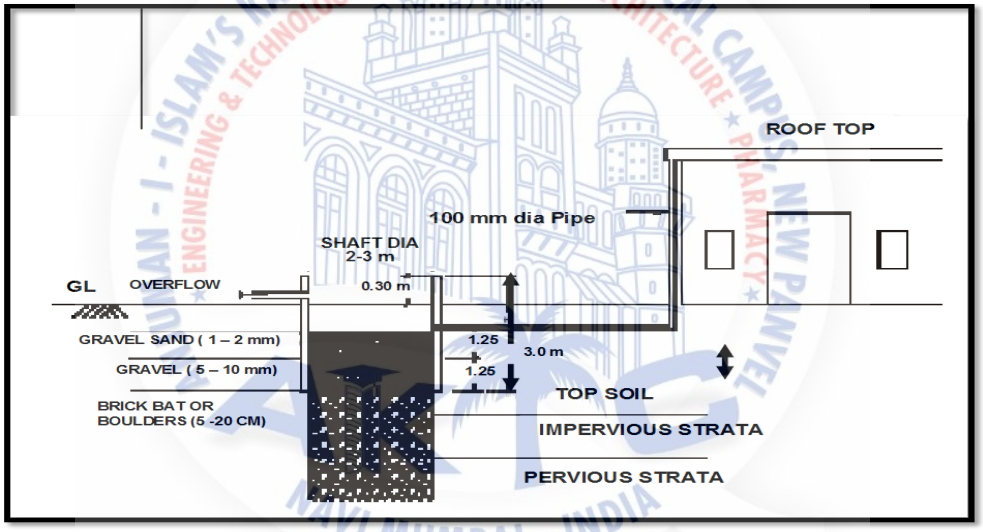


Figure 3.1: Rainwater filter for groundwater recharge

3.1.1 Advantages:

1. Easy to Maintain: Utilizing the rainwater harvesting system provides certain advantages to the community. First of all, harvesting rainwater allows us to better utilize an energy resource. It is important to do so since drinking water is not easily renewable and it helps in reducing wastage. Systems for the collection of rainwater are based on simple technology.

The overall cost of their installation and operation is much lesser than that of water purifying or pumping systems. Maintenance requires little time and energy. The result is the collection of water that can be used in substantial ways even without purification.

2. Reducing Water Bills: Water collected in the rainwater harvesting system can be put to use for several non-drinking functions as well. For many families and small businesses, this leads to a large reduction in their utilities bill. On an industrial scale, harvesting rainwater can provide the needed amounts of water for many operations to take place smoothly without having to deplete the nearby water sources.

It also lessens the burden of soil erosion in a number of areas, allowing the land to thrive once again. In fact, it can also be stored in cisterns for use during times when water supplies are at an all time low.

3. Suitable for Irrigation: As such, there is little requirement for building new infrastructure for the rainwater harvesting system. Most rooftops act as a workable catchment area, which can be linked to the harvesting system. This also lessens the impact on the environment by reducing use of fuel based machines.

Rainwater is free from many chemicals found in ground water, making it suitable for irrigation and watering gardens. In fact, storing large reservoirs of harvested water is a great idea for areas where forest fires and bush fires are common during summer months.

4. Reduces Demand on Ground Water: With increase in population, the demand for water is also continuously increasing. The end result is that many residential colonies and industries are extracting ground water to fulfill their daily demands. This has led to depletion of ground water which has gone to significant low level in some areas where there is huge water scarcity.

5. Reduces Floods and Soil Erosion: During rainy season, rainwater is collected in large storage tanks which also helps in reducing floods in some low lying areas. Apart from this, it also helps in reducing soil erosion and contamination of surface water with pesticides and fertilizers from rainwater run-off which results in cleaner lakes and ponds.

6. Can be used for Several Non-drinking Purposes: Rainwater when collected can be used for several non-drinking functions including flushing toilets, washing clothes, watering the garden, washing cars etc. It is unnecessary to use pure drinking water if all we need to use it for some other purpose rather than drinking.

3.1.2 Disadvantages:

1. Unpredictable Rainfall: Rainfall is hard to predict and sometimes little or no rainfall can limit the supply of rainwater. It is not advisable to depend on rainwater alone for all your water needs in areas where there is limited rainfall. Rainwater harvesting is suitable in those areas that receive plenty of rainfall.

2. Initial High Cost: Depending on the system's size and technology level, a rainwater harvesting system may cost anywhere between $200 to $2000 and benefit from it cannot be derived until it is ready for use. Like solar panels, the cost can be recovered in 10-15 years which again depends on the amount of rainfall and sophistication of the system.

3. Regular Maintenance: Rainwater harvesting systems require regular maintenance as they may get prone to rodents, mosquitoes, algae growth, insects and lizards. They can become as breeding grounds for many animals if they are not properly maintained.

4. Certain Roof Types may Seep Chemicals or Animal Droppings: Certain types of roofs may seep chemicals, insects, dirt or animals droppings that can harm plants if it is used for watering the plants.

5. Storage Limits: The collection and storage facilities may also impose some kind of restrictions as to how much rainwater you can use. During the heavy downpour, the collection systems may not be able to hold all rainwater which ends in going to to drains and rivers.

Rainwater harvesting is a system that is gaining speed over time. Areas that experience high amounts of rainfall will benefit the most from the system and will be able to distribute water to dry lands with ease. However, the beneficial environmental impact of the system is what drives it further as of now.

3.1.3 System setup:

Rainwater harvesting systems can range in complexity, from systems that can be installed with minimal skills, to automated systems that require advanced setup and installation. The basic Rainwater harvesting system is more of a plumbing job than a technical job as all the outlets from the building terrace are connected through a pipe to an underground tank that stores water.

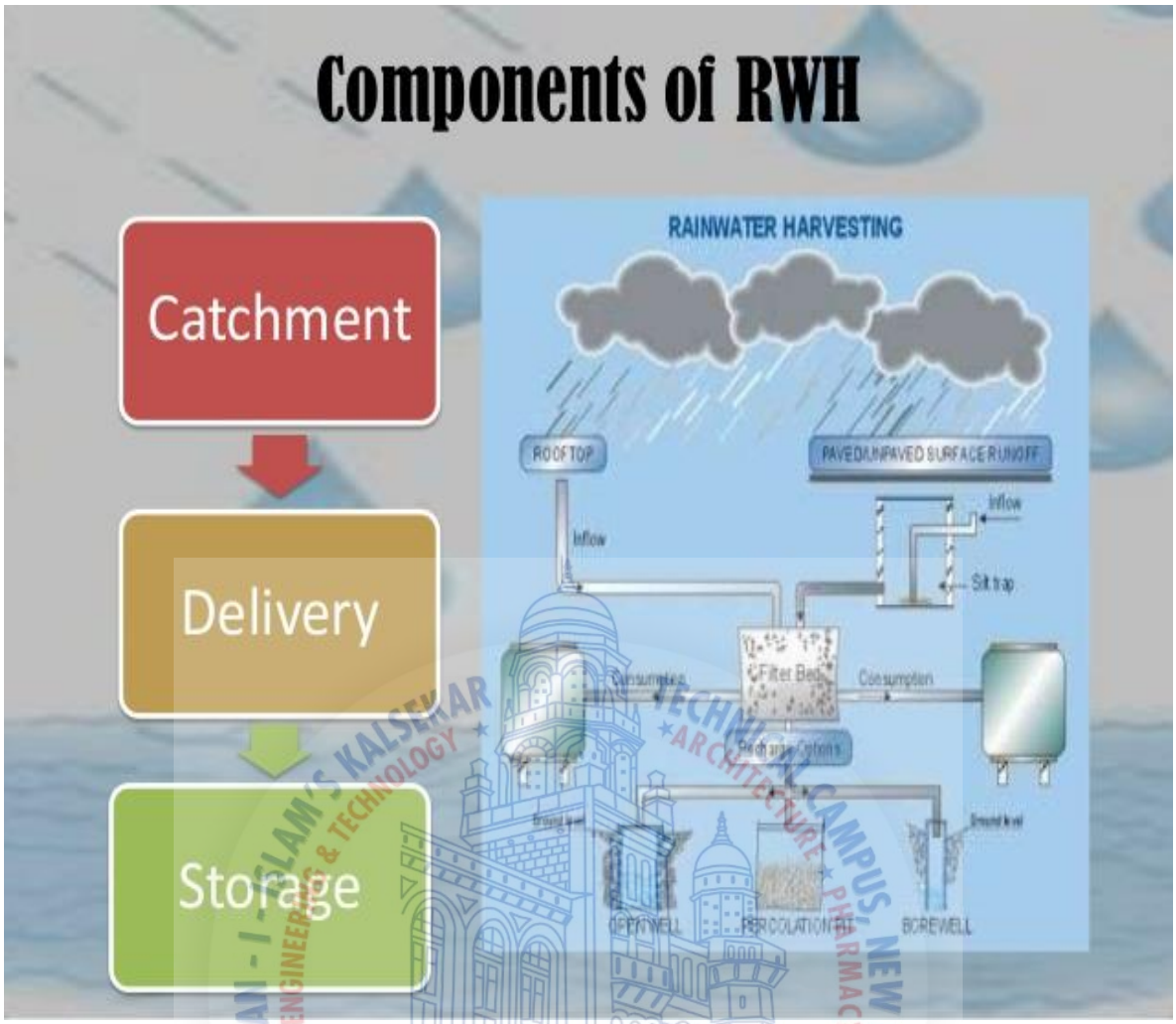


Figure 3.2: System set up of rain water harvesting

Running projects on rain water harvesting:

Systems are ideally sized to meet the water demand throughout the dry season since it must be big enough to support daily water consumption. Specifically, the rainfall capturing area such as a building roof must be large enough to maintain adequate flow. The water storage tank size should be large enough to contain the captured water.

For low-tech systems, there are many low-tech methods used to capture rainwater: rooftop systems, surface water capture, and pumping the rainwater that has already soaked into the ground or captured in reservoirs and storing it into tanks (cisterns).

Before a rainwater harvesting system is built, it is helpful to use digital tools. For instance, if you want to detect if a region has a high rainwater harvesting potential, rainwater harvesting GIS maps can be made using an online interactive tool. Or if you need to estimate

how much water is needed to fulfill a community's water needs, the Rain is Gain tool helps with this. Tools like these can save time and money before a commitment to build a system is undertaken, in addition to making the project sustainable and last a long time.

- **Running projects on rain water harvesting:**

In Malad and other areas of Mumbai, there is an NGO which is doing awareness program on rain water harvesting and installing filters for buildings.

Figure 3.3: Showing the installation of filter

Figure 3.4: Candle type filtering media

Figure 3.5: Rainwater filter at residential building

3.2 Grey water harvesting:

Grey water harvesting (also called gray water), is differentiated from other harvested water sources like rainwater or condensate in that it has already been "gently used"– usually as water from showers and sinks, but it could also be sourced from ponds, pool backwash or process rinse water. It is most often harvested to flush toilets in a building, but the cleaned water can also be used for irrigation and other applications. Toilet waste water and kitchen sink waste water is termed "black water" and is not normally considered for harvested water systems.

The most important advantage of greywater over rainwater for harvesting is that in a residential building – where there are lots of uses of showers and sinks – the greywater provides a constant supply of harvested water for flushing toilets. Our experience is that the greywater supply can usually meet 100% of toilet flushing requirements. And because the

supply is steady and predictable, (unlike rainwater!), the storage requirements are dramatically less, saving storage space and costs.

Harvesting greywater is a relatively new practice in commercial and institutional buildings, and carries many system and regulatory implications not associated with rainwater or condensate harvesting. Unlike other renewable water sources, greywater normally contains biological and chemical contaminants that can quickly turn the water to septic “black water”, resulting in unpleasant odors, colors and health hazards if not treated correctly.

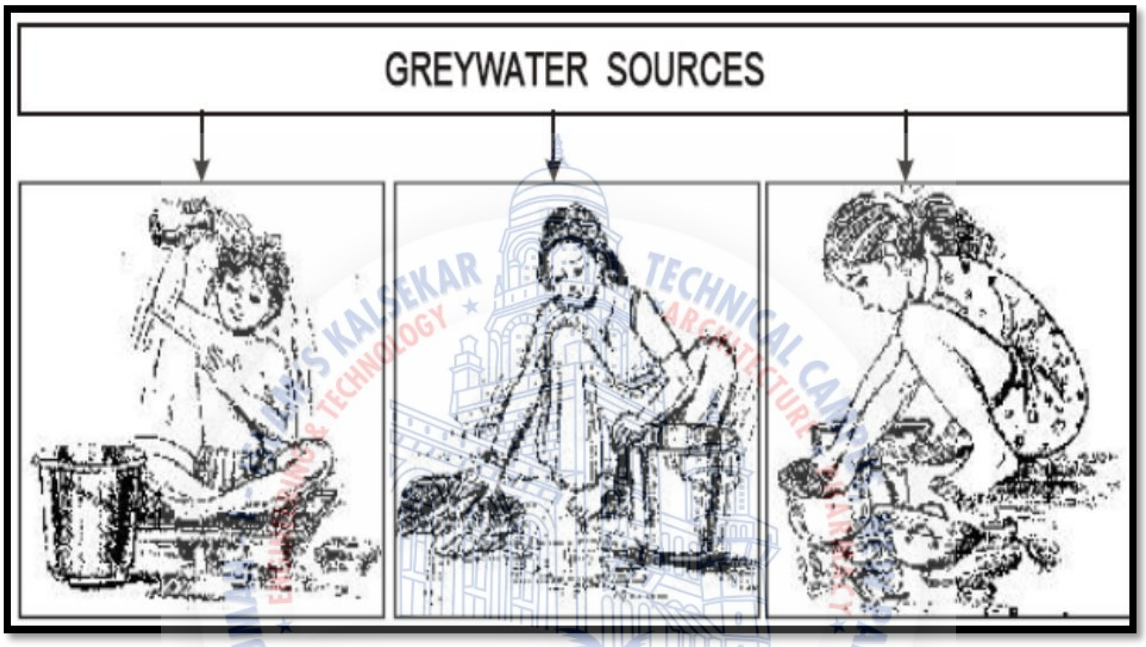


Figure 3.6: Sources of grey water

- **Potential of Grey water Reuse:**

  Reuse of Grey water serves two purposes:

  a) Reduces fresh water requirement

  b) Reduces sewage generation.

The amount and quality of grey water will in part determine how it can be reused. Irrigation and toilet flushing are two common uses, but nearly any non-contact use is a possibility. Toilet flushing can be done either by direct bucketing or by pumping treated grey water to an overhead tank connected by suitable piping to the toilets. Possible uses of treated grey water are presented.

- **Filter**

The type of filter required for a greywater system depends largely upon the amount of greywater to be filtered, the type of contaminants present and end use. A drain filter is an easy and inexpensive way to filter lint and hair out of bath or laundry water. A simple cloth bag tied over the end of a bathroom pipe may be sufficient for irrigating outdoors or similar applications. Filtration is one of the most important operations in the greywater purification process. Though screening and sedimentation process remove a large proportion of suspended matter, they do not effectively remove fine flock particles, colour, dissolved minerals and microorganisms. In filtration, water is passed through a filter medium in order to remove the particulate matter not previously removed by sedimentation. During filtration, the turbidity and colloidal matter of non-settle able type protozoan cysts and helminthes eggs are also removed. Itis to be mentioned that protozoa are stopped in the gravels, the bacteria by the medium grave land the viruses by the sand.

The filter types are as below:

a)Upflow -downflow filter

b) Multi Media Filter

c)Slow Sand Filter

d) Horizontal Roughing Filter

1. Upflow-downflow filter

As the name suggests, raw greywater is put into the bottom of first column of filter and collected at the top of second column. This water is again fed to the third column of filter from the bottom and is collected at the top of fourth column. The number of columns depends on quality of greywater and expected use of greywater and optimally upflow-downflow filter contains four columns. The filter media varies with the column and may contain gravel, coarsesand, fine sand and other material such as wooden chips, charcoal etc. The upflow–downflow filter is shown in Figure 3.4.

2. Multi-media filter

Multi-media filters are filled with a variety of media in order of increasing size, for example, fine sand, coarse sand, gravel, stone, and wood chips to a total depth of 0.75 m to 1 m. The inlet is provided at the top so that the filtered water is collected through outlet in the bottom. A vent is provided at the top for letting out odorous emissions, if generated in the filter. Media can be taken out for washing periodically depending on the greywater characteristics and quantity. Replacement of local filter media is also a feasible alternative.

3. **Slow sand filter**

Slow sand filters are shallow layers of stone, medium gravel, and pea gravel beneath a deep layer of sand. A slow sand filter will have greywater load of 0.1 to 0.2 $m^3/m^2/hr$.

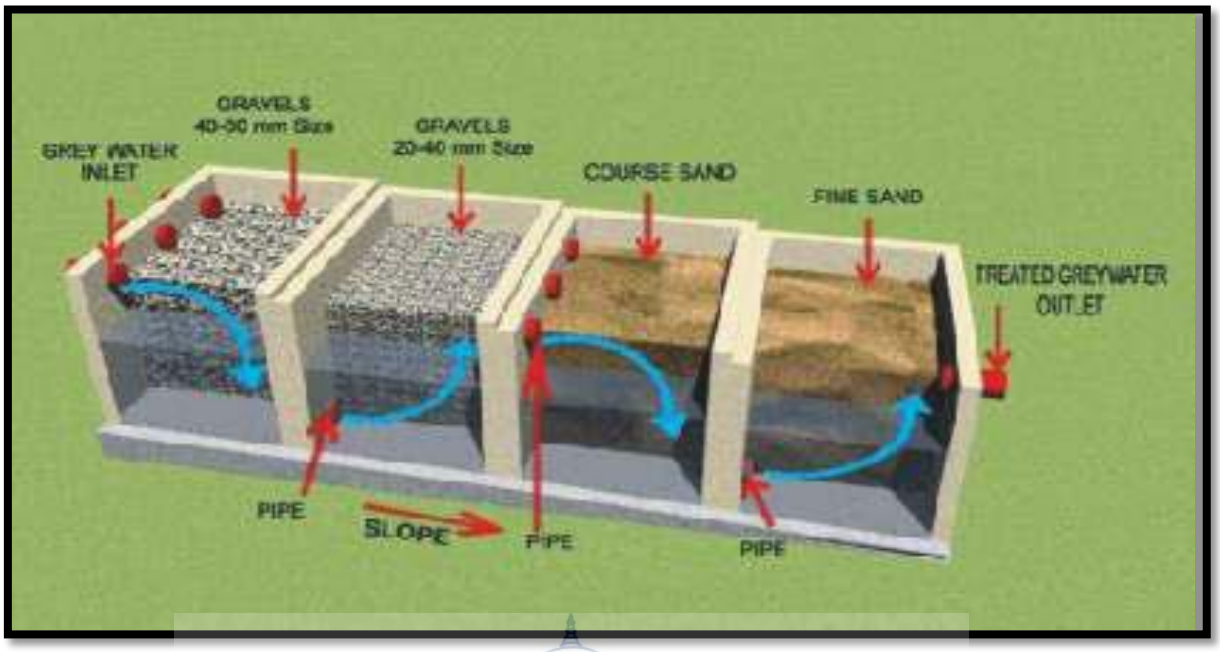


Figure 3.7: Upflow Downflow Filter

These gravity filters may be constructed in a 200 litre drum or similar container that is of suitable size. Features that should be part of a filter include a perforated plate or some other device to distribute water evenly over the top, a concrete funnel in the bottom to help water drain to the perforated drain pipe, and a cover and vent to prevent odours. The bottom of the filter should be filled with stones that are too large to enter the drain pipe. Slow sand filters require regular cleaning and replacement of the top layer of media. Multi-media filters require less frequent cleaning, but all layers must be cleaned or replaced when maintenance is required. Routing greywater through a settling tank before filtering reduces contaminant load and can lengthen the interval between cleanings.

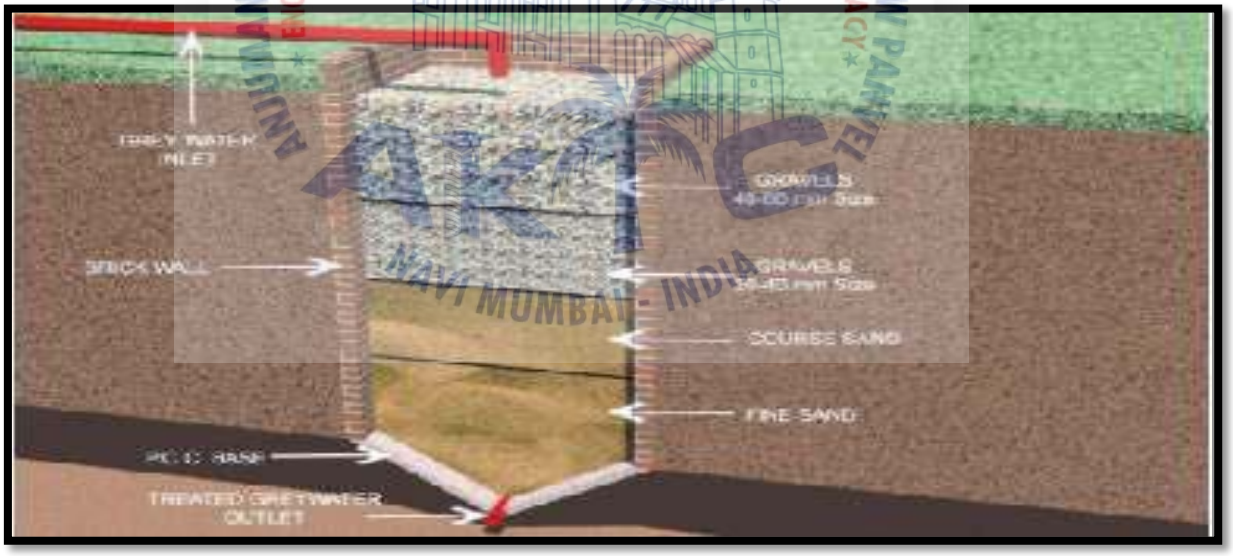


Figure 3.8 Slow Sand Filter

Horizontal Roughing Filter

The horizontal flow prefiltration technique using coarse gravel or crushed stone as a filter media is also a sound alternative in handling turbid waters. The main advantage of the horizontal flow prefilter is that when the raw water flows through it, a combination of filtration and gravity settling takes place which invariably reduces the concentration of suspended solids. The effluent from the pre-filter, being less turbid, can be further easily treated with slow sand filter.

Horizontal flow prefiltration may be carried out in a rectangular box similar to a basin used for plain sedimentation filled with various filter media. The raw water inlet is situated at oneside of the box and the outlet at the opposite side. In the main direction of flow, the water passes through various layers of graded course materials in the sequence coarse-medium-fine.

Table 3.1: Uses of Grey water

Use of Greywater	Purpose
● Individual household	● Toilet flushing
● School	● Floor cleaning
● Government/ non government office	● Irrigation
● Hospital	● Gardening
● Theatre	● Car washing
● Hotel	● Construction
● Airport	
● Railway station	
● Apartment/colony	

3.3 Fixtures and Fastenings:

A faucet is a device that controls the flow of a liquid or gas from a pipe or container. Sinks and baths have faucets attached to them.

The first screw-down tap mechanism was patented and manufactured by the Rotheram brass founders Guest and Chrimes in 1845. Most older taps use a soft rubber or neoprene washer which is screwed down onto a valve seat in order to stop the flow. This is called a "globe valve" in engineering and, while it gives a leak-proof seal and good fine adjustment of flow, both the rubber washer and the valve seat are subject to wear (and for the seat, also corrosion) over time, so that eventually no tight seal is formed in the closed position, resulting in a leaking tap. The washer can be replaced and the valve seat resurfaced (at least a few times), but globe valves are never maintenance-free.

Also, the tortuous S-shaped path the water is forced to follow offers a significant obstruction to the flow. For high pressure domestic water systems this does not matter, but for low pressure systems where flow rate is important, such as a shower fed by a storage tank, a "stop tap" or, in engineering terms, a "gate valve" is preferred.

Gate valves use a metal disc the same diameter as the pipe which is screwed into place perpendicularly to the flow, cutting it off. There is no resistance to flow when the tap is fully open, but this type of tap rarely gives a perfect seal when closed. In the UK this type of tap normally has a wheel-shaped handle rather than a crutch or capstan handle.

Cone valves or ball valves are another alternative. These are commonly found as the service shut-off valves in more-expensive water systems and usually found in gas taps (and, incidentally, the cask beer taps referred to above). They can be identified by their range of motion—only 90°—between fully open and closed. Usually, when the handle is in line with the pipe the valve is open, and when the handle is across the pipe it is closed. A cone valve consists of a shallowly tapering cone in a tight-fitting socket placed across the flow of the fluid. In UK English this is usually known as a *taper-plug cock*. A ball valve uses a spherical ball instead. In either case, a hole through the cone or ball allows the fluid to pass if it is lined up with the openings in the socket through which the fluid enters and leaves; turning the cone using the handle rotates the passage away, presenting the fluid with the unbroken surface of the cone through which it cannot pass. Valves of this type using a cylinder rather than a cone are sometimes encountered, but using a cone allows a tight fit to be made even with moderate manufacturing tolerances. The ball in ball valves rotates within plastic seats.

- **Water Efficient Fittings / Products**

Make it mandatory Water Efficiency Labeling Scheme (MWELS) covering taps, dual flush low capacity flushing cisterns (LCFCs), urinals and urinal flush valves will have a grading system of 0/1/2/3 ticks to reflect the water efficiency of the product. Building owners are encouraged to employ higher rated water efficient labeled products.

Shower taps & mixers
Basin taps & mixers
Sink / Bib taps & mixers
Urinals & urinal flush valves
Dual flush low capacity flushing cisterns

Figure 3.9: Various water efficient fittings

- **Technology that saves water:**

a) Flow Restrictors:

This is a revolutionary technology that lets your taps and showers save upto 80% of water without compromising on the flow. Jaguar flow restrictors adjust the flow in both low and high pressure conditions and offer the same voluminous flow every time.

Figure 3.10: Flow restrictors

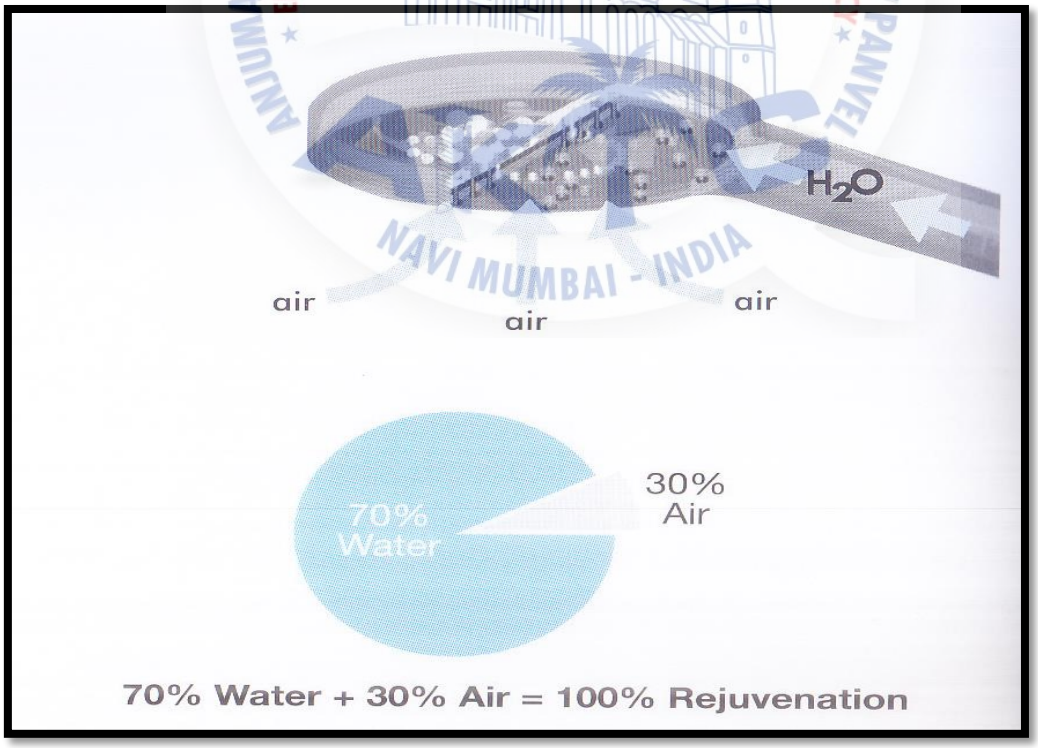


Figure 3.11: Air pressure faucets

- **Pressmatic Faucets:**

Taps with technology that allows only a fixed quantity (750ml) of water to flow with every press of its Knob. This mechanism not only prevents water wastage during each use, but also provides ease of operation. Jaquar pressmatic taps are recommended for bathrooms of high traffic locations like restaurants, clubs, hotels, college, hospital, airports etc.

- **Sensor Faucets:**

Faucets with technology that allows water to flow only when you need it and shuts it as soon as you move your hands away, resulting in zero wastage of water than when you don't need it e.g., while washing hands with soap, you can save water when lathering. Use Jaquar sensor taps in high traffic areas like restaurants, club, hotels, colleges, hospitals, airports etc.

- **Dual flush:**

Flushes that use more water than needed are the biggest water wastage culprits in every home Jaquars dual flushing system enable you to use either a combination of 3/6

litres of water or 2/4 litres of water, depending on your water closet. Jaquars beta valve is designed to save 50-60% of water every day.

Figure 3.12: Water saving products

Chapter 4

Methodology

In this chapter, we discuss about the various methods adopted. All the methods of rainwater harvesting system, grey water, fastening and fixtures are to be discuss with proper explanation and representation.

4.1 Study Area:

As discussed earlier in the section of introduction – management of water by rainwater harvesting, gray water harvesting & fixtures and fastenings we clearly came to know the all the advantages which we can draw out by implementing this small but highly efficient technique in the premises. Thus to increase the potential, benefits of this system and draw maximum advantages from it, we need to have large rooftop areas which will be going to act as catchment areas. More the catchment areas more will be the surface runoff and thus more will be the amount of harvested water.

Therefore as much as possible, we have included and considered all the major buildings having large rooftop areas. Hence, study areas includes all the departmental building (Engineering, Pharmacy & Architecture) and all paved surfaces.

Given below a satellite picture,showing majority of the buildings considered for rainwater harvesting system at AIKTC Campus.

Figure 4.1: GPS View of AIKTC campus

4.1.1 Data Collection:

In this section, we collect all necessary data which are required for our project. (i.e. rain water harvesting and conservation of water).

- **Rainfall Data Collection:**

Panvel is located at 73.1E longitude and 18.98N latitude in Raigarh district of Maharashtra at an elevation of about 12 meters above mean sea level. Raigarh has a tropical climate and receives high rainfall during Southwest monsoon (June-September) and retreating Northeast monsoon (December-January). Average annual rainfall is 1276mm.

Table no. 4.1: Rainfall data of Panvel

Month	Rainfall(mm)
January	0
February	0
March	0
April	10.1
May	20.4
June	590.3
July	1276
August	830.9
September	440.7
October	110.3
November	10.7
December	5.1

The average monthly rainfall data are being taken from The Gazetters Department, Raigad, Maharashtra. Again its followed that, “Panvel” is a small city and thus has a

uniform average rainfall throughout the city in all location. Data of the Panvel city is given below in the table no.1 which is assumed to be same for the station of AIKTC campus.

4.1.2 Determination Of Catchment Area:

The rooftop and paved surface area is nothing but the catchment area which receives rainfall. Catchment areas of the different hostels and Institutional departments are measured. This measurement was done manually with the help of "Measuring Tape and Ultrasonic Distance Measurer (UDM)". Before using the tape, tape was checked for any zero error and also length of the tape was also carefully checked for its accuracy. Those places which area not accessible to land on, are measured by using the ruler from tool box of "Google Earth and Google Measure".

Figure 4.2: Ultrasonic Distance Measurer (UDM)

- **Calculation of rooftop:**

1. Engineering Building= 2837 Sq.m

2. Engineering Lawn= 1078 Sq.m (for ground recharging)

3. Pharmacy Building =1822.413 Sq.m

4. Architecture Building= 1522.272 Sq.m

5. Entrance= 550.000 Sq.m (for ground recharging)

6. Pavement= 968.000 Sq.m (for ground recharging)

Total Area =8777.685 Sq.m

- **Hydrological Analysis**:

On the basis of experimental evidence, Mr. H. Darcy, a French scientist enunciated in 1865, a law governing the rate of flow (i.e. the discharge) through the soils. According to him, this discharge was directly proportional to head loss (H) and the area of cross-section (A) of the soil, and inversely proportional to the length of the soil sample (L).

In other words,

$Q \alpha (H/L)*A$

Here, Q = Runoff, H/L represents the head loss or hydraulic gradient (I), K is the co-efficient of permeability. Hence, finally,

$Q = K* I* A$

Similarly, based on the above principle, water harvesting potential of the catchment area was calculated.

The total amount of water that is received from rainfall over an area is called the rainwater legacy of that area. And the amount that can be effectively harvested is called the water harvesting potential. The formula for calculation for harvesting potential or volume of water received or runoff produced or harvesting capacity is given as:

Harvesting potential or Volume of water Received (m3) = Area of Catchment (m2) X Amount of rainfall (m) X Runoff coefficient.

Runoff coefficient for any catchment is the ratio of the volume of water that runs off a surface to the volume of rainfall that falls on the surface. Runoff coefficient accounts for losses due to spillage, leakage, infiltration, catchment surface wetting and evaporation,

which will all contribute to reducing the amount of runoff. Runoff coefficient varies from 0.05 to 1.0.

In present problem statement, runoff coefficient is equal to 0.9 for the rooftop area is totally impervious and 0.2 for the paved surface area is pervious. Eco-Climatic condition (i.e. Rainfall quantity & Rainfall pattern) and the catchment characteristics are considered to be most important factors affecting rainwater Potential. Given below the table showing the value of runoff coefficient with respect to types of surface areas:-

Table no. 4.2: Value of Runoff Coefficient (K)

Sr No.	Types of Area	Value of "K"		
		Flat land 0-5% slope	Rolling land 5-10% slope	Hilly land 10-30% slope
1.	Urban Areas	0.5	0.65	-
2.	Single family residence	0.33		
3.	Cultivated Areas	0.5	0.6	0.72
4.	Pastures	0.3	0.36	0.42
5.	Wooden land or forested area	0.3	0.35	0.50

Source: Table 7.31, Chapter Hydrology and runoff computation, Irrigation Engineering & Hydraulic Structure, by Garg, S.K.

- **GIS Analysis:**

A geographic information system (GIS) is computer software that allows our young students, researchers and investigators to manage and manipulate interactions between data and geographic locations. GIS technology has the sophistication to go beyond mapping as simply a data management tool. GIS can integrate geo referenced imagery as data layers or themes and link them to other data sets to produce geospatial representations of data. These

geographical pictures not only depict geographic boundaries but also offer special insight to students and researchers across disciplines such as health, economics, agriculture, and transportation.

- **GPS Analysis:**

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS.

4.2 Methods for Storage of Harvested Rainwater In Tank:

Finally, we need to store the water which is obtained from the rooftop areas of the different buildings. The volume of tank which stores the harvested water will be directly proportional to the total volume of water harvested.

Technically, there are two types of methods for distributing the harvested rainwater:

• Rationing Method (RM)

• Rapid Depletion Method (RDM)

To explain these both methods, let us first apply it on AIKTC. The detail calculation is carried out to get the valuable steps. Later on, these crucial steps are again applied to all other building and number of days for consumption of stored water is calculated by using both of these methods.

4.2.1 Rationing Method (RM):

The Rationing method (RM) distributes stored rainwater to target public in such a way that the rainwater tank is able to service water requirement to maximum period of time. This can be done by limiting the amount of use of water demand per person.

Suppose in this method, the amount of water supplied to student is limited which is equal to say, 70 lit/day per capita water demand for AIKTC.

Population of AIKTC = 2634

Then,

Total amount of water consumption per day = 2634x0.07 = 184.38 m^3/day

Total no. of days we can utilize preserved water = stored water/water demand

volume of water stored in tank = 6326 m^3

Hence finally,

no of days = 6326/184.38 = 34.30 days

For long term storage of preserved water in good condition, preserving chemical should be added.

4.2.2 Rapid Depletion Method (RDM):

In Rapid Depletion method, there is no restriction on the use of harvested rainwater by consumer. Consumer is allowed to use the preserved rain water up to their maximum requirement, resulting in less number of days of utilization of preserved water. The rainwater tank in this method is considered to be only source of water for the consumer, and alternate source of water has to be used till next rains, if it runs dries.

For example if we assume per capita water demand = 90 lit/day = 0.09 m^3/day

Total amount of water consumption per day = 2634 x 0.09=237.06m^3/day

Total no. of days, preserved water can be utilize = stored water/water demand =2634/237.06 = 11.11 days

Hence, finally it is observed that, if the amount of water stored is equal to 2634 m^3,

then applying,

1. (Rapid Depletion Method), consumer can utilize the preserved stored water for about 34.30 days

2. Where as in (Rational Method), preserved stored water can be utilized for a period of 11.11 days

4.3 Procedure:

We will collect the water from rooftop area. The collect rainwater will pass from the pipeline which will be drawn specially for rainwater which will pass through a filter.

The filter is a candle like structure from inside which has a mesh of 20micron and it can work for area of 1000sq.ft. It has 16 mesh inside it which remove colloidal and suspended particles. It has to be cleaned once in a week and in case of heavy rainfall it has to be cleaned twice a week.

- **Optimistic Determination of Size And Type of Tank:**

Just to start with, now let us consider area of campus proceed with calculation in details. AIKTC building is the present study area. This building presently has capacity of 2634 population including staffs. This building is made up of 3 buildings (Architecture, Pharmacy, Engineering), it has continuous paved mess roof and road paved areas as shown.

The total rooftop and paved area of the campus is 8777.685 sq.m. The cumulative runoff that can be captured from the paved area is calculated.

The tank capacity can be estimated to be a lower value accounting for the continuous consumption going on during period of rainfall. Total roof and paved area of AIKTC building was calculated = 8777.685 sq.m

Average annual rainfall at Panvel = 1276 mm/year = 1.276 m/year

Total volume of surface runoff water suppose to be collected (the average runoff coefficient is 0.80 for different surfaces) = 8777.685 x 0.80 x 1.276 = 8960.26 m^3/year

4.4 Types of Tank:-

Two type of tank can be used for storing of rainwater discharged from the roof:

• Lined Storage Tank

• Unlined Natural Storage Tank

In lined storage tank, earth work excavation is done and Underground RCC water storage tank is constructed which is completely covered from the top. The land above the tank can be used for serving as playground or parking slot, etc.

In unlined natural storage tank, earth excavation is done and all the water being allowed to fall directly in that pit and store it. In this method, we get two advantages.

Firstly, our natural water gets recharged leads to augmentation of water level and ground condition, increasing prospects for better future cultivation and plantation. Secondly, underground water can be extracted anywhere within some limited areas from that pit and can be used to satisfy daily water demand.

4.5 Analysis & Design of Underground Sump:

- **Design of Tank:**

Given below the complete design of all the components of rainwater harvesting of AIKTC whose dimensions are mentioned and tank size is 9.5 x 4.5 x 4.

Problem Statement :

Height of tank= 4m,

free board = 0.3m

Taking subsoil consists of sand, angle of repose = 30^0

Saturated unit weight of soil = 18 KN/m^3

Water table likely to rise up to ground level

M25 concrete, HYSD bar

Unit weight of water = 9.81 KN/m^3

Solution:

There are four components of design:-

i) Design of long wall

ii)Design of short wall

iii)Design of base slab

iv)Design of roof slab

- **Design of wall be done under two condition:-**

a) Tank full with water, with no earth fill outside

b) Tank empty with water, with full earth pressure due to saturated earth fill.

As the ratio of L/B = 9.5/4.5 = 2 is equal to 2, the long walls will be designed as cantilever and short walls as slab supported by long walls. Bottom 1m of short wall shall be designed as cantilever.

- **Estimation and Design:**

Long wall:

Case 1 (tank empty) :

Pressure of saturated soil acting from outside and no water pressure inside.

Depth of water = 4 – 0.3 = 3.7m

P = 9810 x 3.7 + (18000 – 9810) x 3.7 x [(1-sin30)/(1+sin30)]

= 46296.99 N/m

Max. BM at base of long wall (from fig.)

46296.99 x 3.7 x 3.7/3 = 105634 N.m

Depth required for no cracking,

1000 x D2/6 x 1.8 = 105634 x 1000

D = 593.38 = 600 mm

Provide D = 600 mm with effective cover of 40 mm, d = 560 mm

Astreq = (105634 x 1000) / (0.9 x 150 x 560) = 1397.22 mm^2

Spacing = 201.06 x 1000 / 1397.22 = 143.9 mm = 140 mm c/c

Provide 16mm dia bars @ 140 mm c/c vertically on outside face upto half the height of the wall and thereafter curtail alternate bars for 2m from bottom of tank. Estimation and Design

Direct compression is caused in long walls because of earth pressure acting on short walls, which is generally of little effect.

Case 2: (tank full):

Pressure of water acting from inside and no earth pressure from outside.

Max BM due to water pressure = 9810 x 3.73 / 6

= 82817.65 N.m < 105634 N.m

Therefore, thickness of wall provided i.e. OK.

Ast = 82817.65 x 1000 / (0.9 x 150 x 560) = 1095.47 mm^2

Spacing = 201.06 x 1000 / 1095.47 = 183.53 mm = 180 mm c/c

Provide 16mm dia bars @ 180 mm c/c vertically on outside face upto half the height of the wall and thereafter curtail alternate bars for 2m from bottom of tank.

Astdist = (0.24/100) x 1000 x 600 = 1440 mm^2

Area of steel per face = 1440/2 = 720 mm^2

Spacing = 78.53 x 1000 / 720 = 109.08 mm c/c

Provide 10mm dia bars @ 100 mm c/c vertically in long walls.

Direct tension in long walls.

Since the long walls are to get their support from the long walls, direct tension shall be caused in long walls.

Direct tension at 1m above the base = 9810 x (3.7-1) x 4.5/2 = 59580 N

Area of steel required in 1m height = 59580/150 = 397.2 mm^2

Therefore, no additional steel is required.

Short wall:

Case 1 (tank empty):

Pressure of saturated soil acting from outside and no water pressure from inside

Bottom 1m height.

BM = (36297+9999.99) x 1/6

=7716.165 N.m

For no cracking, for M25 concrete, as per IS code,

1000 x D2/6 x 1.8 = 7716.165 x 1000

D = 160.37 mm < 600 mm

Ast = (7716.165 x 1000) / (0.9 x 190 x 560) = 805.78 mm^2

Distribution steel (vertical) of top 2.7m is sufficient. Therefore OK.

Wall above 1m from base,

Total pressure = (9810 x 2.7) + (0.33 x 2.7 x 8190) = 33784.29 N/m^2

BM at support = $pl_2/12$

= (33784.29 x 5.12) / 12 = 73227.448 N.m

BM at mid span = $pl_2/16$

= (33784.29 x 5.12) / 16 = 54920.586 N.m

Thickness of wall at junction of short wall with long wall with no cracking

1000 x D2/6 x 1.8 = 73227.448 x 1000

D = 494.056 mm < 600 mm

Therefore, providing a haunch of 100mm x 100mm for safety as shown

Here, D = 700, d = 660.

Ast at support = 73227.448 x 1000 / (190 x 0.9 x 660) = 648.83mm^2

Spacing = 113.09 x 1000 / 648.83 = 174.29 mm

Provide 12 mm dia bars @ 150 mm c/c in one meter height, on outer face horizontally, which may be increased uniformly to 200 mm c/c near top of the wall.

Ast at centre = 54920.586 x 1000 / (150 x 0.9 x 560) = 726.46 mm^2

Spacing = 113.09 x 1000 / 726.46 = 155.67 mm

Case 2 (tank full):

Pressure of water from inside and no earth pressure from outside

Bottom 1m height of wall

Pressure at bottom = 9810 x 3.7 = 36297 N/m^2

BM = (1/2) x 36297 x 1 x (1/3) = 6049.5 N.m

Minimum reinforcement is OK

Wall pressure at 2.7m depth = 9810 x 2.7 = 26487 N/m^2

BM at support = $pl_2/12$ = 26487 x 5.12 / 12 = 57410.57 N.m

BM at centre = $pl_2/16$ = 26487 x 5.12 / 16 = 43057.929 N.m

Direct tension from end 1m of long wall = 26487 x 1 = 26487 N/m height

Net BM at support = 57410.57 – 26487[0.66 – (0.7/2)] = 49199.6 N.m

Ast = 49199.6 x 1000 / (0.9 x 150 x 660) = 552.18 mm^2

Spacing = 78.53 x 1000 / 552.18 = 142.21 mm = 140 mm c/c

Provide 10 mm dia bars @ 140 mm c/c on inside face horizontally which may be increased uniformly to 180 mm c/c near the top of the wall.

Net BM at centre of span = 43057.929 – 26487 x 0.31 = 34846.959 N.m

Ast = 34846.959 x 1000 / (0.9 x 190 x 560) = 363.89 mm^2

Spacing = 78.53 x 1000 / 363.89 = 215.80 = 200 mm c/c

Provide 10 mm dia bars @ 200 mm c/c on outer face horizontally which may be uniformly increased to 250 mm c/c near the top of the wall.

BASE SLAB:

For 350 mm thick, M25

Check against uplift

Projection of 0.3m beyond the face of the wall is provided to add the stability uplift.

Weight of vertical walls

Long walls = 2 x 9.6 x 0.6 x 4 x 25000 = 1152000 N

Short walls = 2 x 5.1 x 0.6 x 4 x 25000 = 612000 N

Base slab = (9 + 0.6 x 2 + 0.3 x 2) (4.5 + 0.6 x 2 + 0.3 x 2) x 0.35 x 25000 = 595350 N

Weight of earth on projections:

= (10.8 x 2 + 4.5 x 2) 3.7 x 0.3 x 18000

= 611388 N

Uplift due to pressure of ground on water tank

= 10.8 x 6.3 x 3.7 x 9810

= 2469647.88 N

Total downward weight = 1152000 + 612000 + 595350

= 2359350 N

Frictional resistance required = 2469647.88 – 2359350

= 110297.

Pressure of submerged earth and water at the depth of[(3.7 + 0.35) = 4.05 m]

= 9810 x 4.05 + (1/3) x (18000 - 9810) 4.05 = 50787 N/m^2

Total pressure per meter length of wall = 50787 x 4.05 x (1/2)

= 102843.675 N/m

The angle of repose of soil will be low as it is saturated. Assuming coefficient of friction as 0.15 frictional resistance per meter length of wall. = 0.15 x 102843.675 = 15426.55 N

Total frictional resistance from 4 sides walls:

= 15426.55 x (5.7 + 10.2) x 2

= 490564.29 N > 110297.88 N (safe).

Consider one meter length of slab, upward pressure of water per square meter = 3.7 x 9810

= 36297 N/m^2

Self weight of slab = 1 x 1 x 0.35 x 25000 = 8750 N/m^2

Net upward pressure = 36297 – 8750 = 27547 N/m^2

Weight of wall per meter run = 0.6 x 4 x 25000 = 60000 N/m

Weight of earth on projection = 18000 x 3.7 x 0.3 = 19980 N/m

Net unbalanced force = 27547 x 6.3 – 2 x (60000 + 19980) = 13586.1 N

Reaction on each wall = 13586.1 / 2 = 6793.05 N

B.M. at edge of cantilever portion

= (27547 x 0.32/2) + {46398 x (3.7/2) x (3.7/3)} – (19980 x 0.3)/2 = 104107.31 N.m

B.M. at centre of span

= (27547 x 6.32/8) + 46398 x 3.7 x 3.7/3 – (6793.05 + 60000) x ((6.3/2) – 0.3 – (0.6/2)) – 19980 x ((6.3/2) – 0.15)

= 136667.55 + 211729.54 – 170322.27 – 59940 = 118134.796 N.m

For no cracking, 1000 x D2/6 x1.8 = 104107.31 x 1000

D = 589.08 mm, = 600mm, d = 600 – 40 = 560 mm

Area of steel required at support = 104107.31 x 1000/ 150 x 0.9 x 560 = 1377.08 mm^2

Min reinforcement = 0.3 x 600 x 1000 / 100 = 1800 mm^2

Provide 12 mm dia @ 110 mm c/c and distribution as 12 mm dia @ 160 mm c/c each face.

Maximum S.F. = 6793.05 + 60000 + 19980 – 27547 x (0.3 + 0.6)

= 61980.75 m

Nominal shear stress = 61980.75 / 560 x 1000 = 0.1106 N/mm2 < 1.5 N/mm^2…… (safe).

- **Detail Costing and Estimation of Sump (Underground Tank):**

Finally cost of entire project play a crucial role in any type of project. Before implementing the project, it is highly necessary for the engineers to check project, whether it is economical or not. Hence, the detail cost estimation should be done. Tank shall be of 1:3:6 cement concrete. Wall thickness is about 600mm. Roof covering slabs shall be precast R.C.C. The length of the connecting pipe from latrine seat may be taken as 3 meters. And suitable rates are assumed.

Given below the detail cost estimation of constructing an underground sump of dimension (9 x 4.5 x 4 m).

- **Estimation For Tank: Dimension (9 x 4.5 x 4m):**

• Quantity Of Concrete (1:3:6) Proportion:

Base Slab: (10.8 x 6.3 x 0.6m)

Thickness of base slab = 0.6m

Volume of concrete = 10.8 x 6.3 x 0.6 = 40.824 m^3

Considering 1 cu m wet vol. = 1.54 cu m dry vol.

Quantity of cement for (1:3:6 prop) = 40.824 x 1.54 / 10= 6.28 cu m.

(1 bag of cement = 0.0347 cu m). No of cement bags = 6.28 / 0.0347 = 181.17 bags.

Quantity of sand = 6.28 x 3 = 18.84 cu m.

Quantity of aggregate = 6.28 x 6 = 37.68 cu m.

Table no. 4.3: Quantity of materials for slab

INGRIDIENTS	**CEMENT (no of bags)**	**SAND (cu.m)**	**AGGREGATES (cu.m)**
TOTAL VOLUME (for slab)	**182 nos.**	**18.84**	**37.68**

Short Wall:

(as a vertically slab of dimensions 5.7 x 4 x 0.6)

Thickness of wall = 0.6m

Volume of concrete = 5.7 x 4 x 0.6 = 13.68 m^3

Considering 1 cu m wet vol. = 1.54 cu m dry vol.

Quantity of cement for (1:3:6 prop) = 13.68 x 1.54 / 10 = 2.10 cu m.

(1 bag of cement = 0.0347 cu m). No of cement bags = 2.10 / 0.0347 = 60.71 bags.

Quantity of sand = 2.10 x 3 = 6.3 cu m.

Quantity of aggregate = 2.10 x 6 = 12.6 cu m.

Table no. 4.4: Quantity of materials for short wall

INGREDIENTS	**CEMENT (no of bags)**	**SAND (cu.m)**	**AGGREGATES (cu.m)**
TOTAL VOLUME (For 2 short wall)	**122 nos.**	**12.6**	**25.2**

Long Wall:

(as a vertically slab of dimensions 9 x 4 x 0.6m)

Thickness of wall = 0.6m Volume of concrete = 9 x 4 x 0.6 = 21.6 m^3

Considering 1 cu m wet vol. = 1.54 cu m dry vol

Quantity of cement for (1:3:6 prop) = 21.6 x 1.54 / 10 = 3.33 cu m.

(1 bag of cement = 0.0347 cu m). No of cement bags = 3.33 / 0.0347 = 95.86 bags.

Quantity of sand = 3.33 x 3 = 9.99 cu m.

Quantity of aggregate = 3.33 x 6 = 19.98 cu m.

Table no. 4.5: Quantity of materials for long wall

INGREDIENTS	**CEMENT (no of bags)**	**SAND (cu.m)**	**AGGREGATES (cu.m)**
TOTAL VOL. (for 2 long wall)	**192 nos**	**19.98**	**39.96**

FOR BASE SLAB: (10.8×6.3×0.6m)

Weight of bar kg/m = (dia of bar)^2/ 162

Table no. 4.6: Quantity of reinforcement required for base slab

Size of bar and position	Overall length	Extra length (hook 9D) (m)	Cover (m)	Actual length (m)	Nos of bars	Total length (m)	Weight (kg)
12mm dia straight @ 110mm c/c	**6.3**	**2×6× 0.12 =1.44**	**0.04× 2 =0.08**	**7.66**	**(10.8/0.11) + 1= 100 no**	**766**	**Col7×0.89kg/m 681.74**
12mm dia straight @ 160mm c/c	**10.8**	**2×6× 0.12 =1.44**	**0.04× 2 =0.08**	**12.16**	**(6.3/0.16) + 1= 41 no**	**498.56**	**Col7×0.89kg/m 443.72**

Total wt of reinforced required= 681.74 +443.72

=1125.46kg

For both face of slab reinforced required= 2 × 1125.46 = 2250.92kg= 22.51quintals

SHORT WALL: (5.7×4×0.6m)

Weight of bar kg per metre= (dia of bar)^2 / 162

QUANTITY OF REINFORCED REQUIRED FOR SHORT WALL

Total wt of reinforcement required = 205.69+193.87 =399.568 kg

For both face of short wall reinforcement required = 2×399.568 = 799.136 kg = 7.991 quintals.

Table no.4.7: Quantity of reinforcement required for short wall

Size of bar and position	Overall length	Extra length (hook 9D) (m)	Cover (m)	Actual length (m)	Nos of bars	Total length (m)	Weight (kg)
10mm dia straight @ 100mm c/c	4.0	2×9×0.1 =1.8	0.04×2 =0.08	5.72	(5.7/0.1) + 1= 58 no	331.76	Col7×0.62kg/m 205.69
12mm dia straight @ 150mm c/c	5.7	2×9×0.12 =2.16	0.04×2 =0.08	7.78	(4.0/0.15) + 1= 28 no	217.84	Col7×0.89kg/m 193.878

There are two short wall, hence,

Steel required for both walls = 2×7.991 = 15.982 quintals

LONG WALL:(9×4×0.6m)

Weight of bar kg per metre = (dia of bar)^2/162

Table no.4.8: Quantity of reinforcement required for long wall

Total wt of reinforcement required = 272.5+526.07 = 798.57 kg

Size of bar and position	Overall length	Extra length (hook 9D) (m)	Cover (m)	Actual length (m)	Nos of bars	Total length (m)	Weight (kg)
10mm dia straight @ 100mm c/c	9.0	2×9× 0.1 =1.8	0.04× 2 =0.08	10.72	(4/0.1) + 1= 41 no	439.52	Col7×0.62kg/m 272.50
16mm dia straight @ 140mm c/c	4.0	2×9× 0.16 =2.88	0.04× 2 =0.08	6.8	(9/0.14) + 1= 66 no	443.94	Col7×1.58kg/m 701.42×0.75 (half bar curtailed) = 526.07

For both face of long wall reinforcement required = 2×798.57=1597.14kg =15.9714 quintals

There are two long wall, hence steel required for both walls = 2×15.9714 =31.943 quintals

Table no.4.9: Overall quantity of particulars of items of tank

Particulars of items	Cement (no of bags)	Sand (cu m)	Aggregate (cu m)	Reinforcement (quintals)
Overall quantity	496	51.42	102.84	70.435

Table no.4.10: Measurement sheet for tank

Sr no.	Description of item	Length (m)	Breadth (m)	Height (m)	Quantity (m^3)
1	Excavation of earth	11	6.5	4.1	293.15

Table no.4.11: Abstract sheet of estimated quantities for tank

Items no.	Particulars of item	Quantity	Unit	Rate per unit (Rs.)	Unit of rate	Amount (Rs.)
1	Excavation	293.15	Cu.m	392	Per cu.m	106120.3
2	Cement	496	No of bags	450	Per bag	223200
3	Sand	51.42	Cu.m	1500	Per cu.m	77130
4	Aggregate	102.84	Cu.m	2200	Per cu.m	226248
5	Reinforcement	70.435	Quintal	3500	Quintals	246522.5

Total Cost= Rs. 879220.8

Add 2.5%, 5% water establishment & contigency respectively= Rs. 61545.45/-

Total estimated cost= Rs 940766.256/-

Grey water:

Our study area is AIKTC campus where the water which comes under grey water is from wuzu and wash basin. The population of AIKTC campus is 2634 including students and staff. As this is an Institution so the daily water demand is 70lpcd (assumed), from which waste water will be 30lpcd (assumed). So the daily grey water generated will be calculated as under,

Total grey water = Population × discharge per capita per day

= 2634 × 30

= 79020 litres/day

As above calculation we can see the daily grey water from this institute is 79020.If 50% is treated by locally available filters i.e. sand and gravel filter, we can reuse this water for gardening and washing of floors on daily basis.

We will use sintex tank of 2000 litres for storage of this water. So the number of tank will be,

79020/2000 = 39.51 = 40 tanks (approx.)

But we will use 6 tanks for storing the water as the whole water is not coming at the same time. The water will be collecting and using after every 6hrs. Or it can be connected to the toilet flushes.

The cost of one tank is Rs.15000/- and we are providing 6 tanks therefore total cost of tank will be,

6×1500 = Rs.90000/-

As the initial cost of reusing this grey water is high but we can reduce the demand of fresh water and can also reduce the load of municipality.

FAUCETS:

SINGLE LEVER BASIN MIXER

Price: Rs.3000/-

MODEL NO.- LYR-CHR-38001B

Figure 4.3: Single lever basin mixer

MECHANISM:

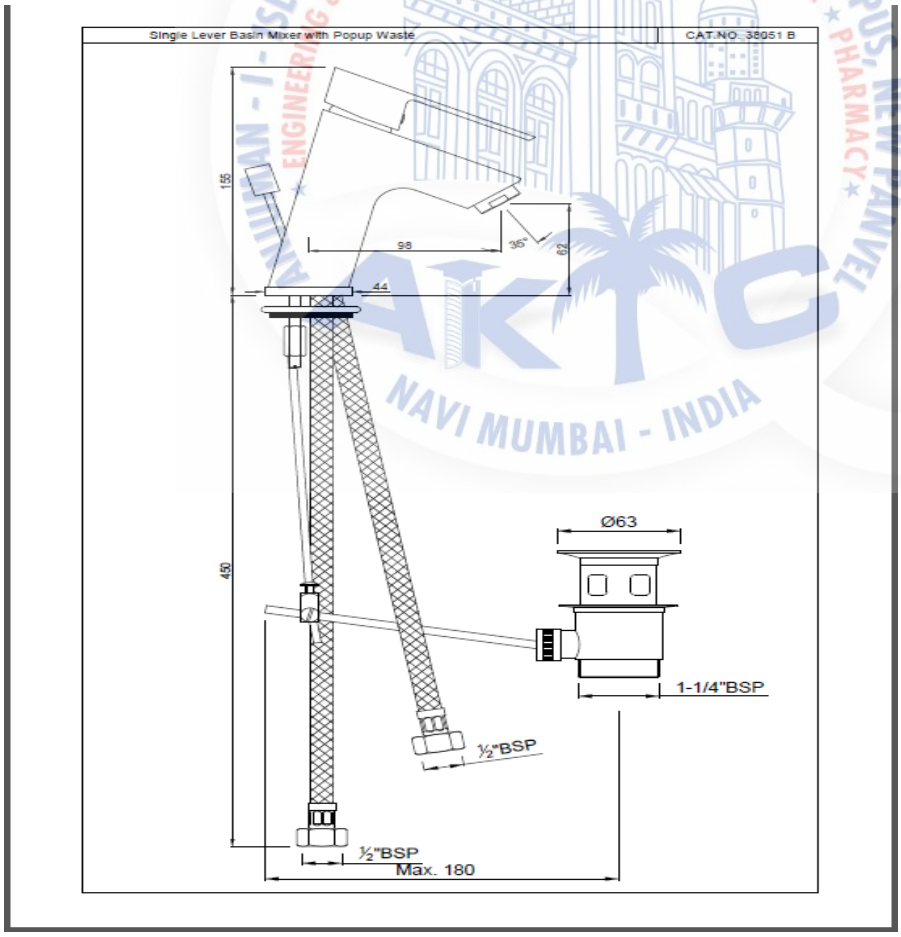


Figure 4.4: Mechanism of Single lever basin mixer

SENSOR TAPS:

PRICE: Rs. 9000/-

MODEL NO.- SNR-CHR-51021

Figure 4.5: Sensor taps

MECHANISM:

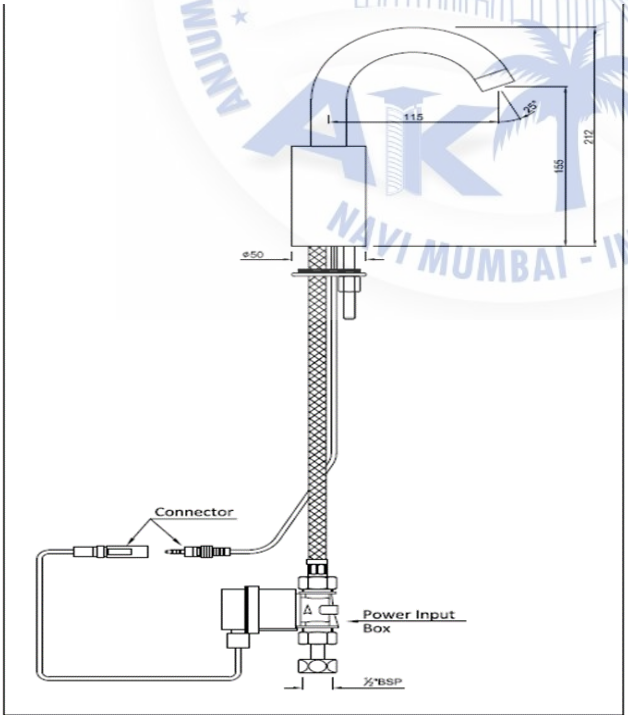


Figure 4.6: Mechanism of sensor taps

SINGLE LEVER BASIN MIXER

PRICE: 49000/-

MODEL NO.- FUS-CHR-29052B

Figure 4.7: Single lever basin

SPONT OPERATING TAP:-

PRICE: Rs.1500/-

MODEL NO.- SOT-CHR-83011

Figure 4.8: Spont operating tap

No. of Taps- 298 Taps

Providing following types of faucets and fittings to save water:

- **Low cost:**

  Spout operating taps (SOT-CHR-83011):

  The cost of 1 tap is Rs.1500/-

  There are 298 taps in the premises, therefore total cost of taps will be

  = 298×1500 = Rs.447000/-

- **Medium cost:**

  Single lever basin mixer (LYR-CHR-38001B):

  The cost of 1 tap is Rs.3300/-

  Hence,

  = 298×3300 = Rs.983400/-

- **High cost:**

  Single lever extended basin mixer (FUS-CHR-29052B):

  The cost of 1 tap is Rs.4900/-

  Hence,

  = 298×4900 = Rs.1460200/-

- **Sensor:**

  Automatic sensor(SNR-CHR-51021):

  The cost of 1 tap is Rs.9000/-

  The total cost will be,

  = 298×9000 = Rs.2682000/-

CHAPTER 5

CONCLUSION

1) RAINWATER HARVESTING

Table 5.1: Result of rainwater harvesting

Items no.	Particulars of item	Quantity	Unit	Rate per unit (Rs.)	Unit of rate	Amount (Rs.)
1	Excavation	293.15	Cu.m	392	Per cu.m	**106120.3**
2	Cement	496	No of bags	450	Per bag	**223200**
3	Sand	51.42	Cu.m	1500	Per cu.m	**77130**
4	Aggregate	102.84	Cu.m	2200	Per cu.m	**226248**
5	Reinforcement	70.435	Quintal	3500	Quintals	**246522.5**

Total Cost= Rs. 879220.8

Add 2.5%, 5% water establishment & contingency respectively= Rs. 61545.45/-

Total estimated cost= Rs 940766.256/-

2)GREY WATER HARVESTING:

The cost of one tank is Rs.15000/- and we are providing 6 tanks therefore total cost of tank will be,

6×1500 = Rs.90000/-

As the initial cost of reusing this grey water is high but we can reduce the demand of fresh water and can also reduce the load of municipality.

3) FIXTURES AND FASTENINGS

Table 5.2: Result of fixtures and fastenings

Types of faucets	Efficiency	Cost
Low cost	1.No leakage proof 2.	**447000**
Medium cost	1. Flow rate: 5 l/min at 3 bar 2. Operating pressure: min. 1bar/max. 10 bar 3. Push-open waste 1 1/4th	**983400**
High cost	1.Minimum operating Pressure: 0.2 bar LP 2.Flow rate at 3 bar pressure 3.Aerator: 14, Flow st: 20 l/min 4.Guarantee: 12 year guarantee	**1460200**
Sensor	1.Can save water by 30% to 50% by placing sensor taps in the premises.	**2682000**

REFERENCES

1) **Rainwater Harvesting at National Institue Of Technology, Rourkela by Mr Ranjit Kumar Sharma**
2) **Estimating, costing, specification and valuation by M. Chakraborti**
3) **Irrigation Engineering and hydraulic structure by SK Garg**
4) **Arun Kumar Dwivedi and Sudhir Singh Bhadauria (2009)**
5) Shaikh, Sk Sameer, Sk Younus (2014)
6) **Abeer Albalawneh, Tsun-Kuo Chang (2015)**
7) **International Journal of Scientific & Engineering Research, Volume 4, Issue 8, (August-2013)**

Web Portal Support (INTERNET):

1. **http://as.or.nic/balangir/rainfall/pubNormaldtl.asp**
2. **http://www.rainwaterharvesting.org**
3. **http://www.tn.gov.in/dtp/rainwater.htm**
4. **http://www.rainwaterharvesting.com/**
5. **http://www.rainwaterharvesting.org/People/innovators-urban.htm#svis**
6. **http://www.agri.mah.nic.in**

Abbreviations

1. IMD: Indian Meteorological Department
2. BCM: Billion Cubic Meters
3. NCIWRD: National Commission on Integrated Water Resources Department
4. CGWB: Central Ground Water Board
5. BIS: Bureau of Indian Standards